International
Water Association

WATER RECYCLING AND REUSE:

Potential, Safety and Best Practices

The implementation of water recycling and reuse requires a global framework that considers institutional, financial and practical aspects to enable local stakeholders to manage recycled water safely

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WHEN AND WHY TO RECYCLE TREATED WASTEWATER?

1) Alleviate Chronic or Temporal Water Shortages

- Drought-proof alternative resource available near the point of use at lower cost, if treatment limited to fit-for-purpose,
- Complementary water resource for coastal areas, where discharges into the sea are damaging, and in addition, can be used as a barrier to seawater intrusion,
- Viable alternative to the import and transfer of natural resource, i.e., water transfer over long distances,
- Conflict-balancing factor, i.e. agriculture or industry versus domestic supply, ensuring a higher degree of water independence,
- Step towards a greater sustainability in dry climate settlements, both urban and rural.

Key Market Drivers

- Water scarcity and droughts
- New water policies and regulations
- Integrated resource management
- Sustainable development
- Environmental protection

Key Market Restraints

- Water pricing and subsidized water rates
- Needs for funding, economic viability, economy of scale
- Lack of consistent legislation, policies and regulations
- Possible negative public or media perception

2) Implement New Water Policies and Regulations for Water Conservation, Sustainability, and Environment Protection

- Viable option to reduce nutrient discharge to the environment, add fertilising value to irrigation water and decrease nutrient removal costs of wastewater treatment,
- Potential lower energy and ecological costs compared to other resource generation activities, i.e. deep groundwater extraction, long-distance importation, impoundment construction or desalination,
- Good solution to increase local ecological benefits and favour tourism through the creation of wetlands, restoration of polluted resources and maintenance of green landscapes,
- Relevant solution for environmental protection in combination with additional measures for water conservation and source reduction (salts, nutrients, urine separation, etc.),
- Substitute drinking water supply for a number of non-potable purposes (fisheries, irrigation, urban and industrial uses), increasing water availability and flexibility, decreasing net water demand and adding value to water.

Water Reuse for Sustainable Supply

Widely practiced and with high economic value

- Industrial uses: cooling, boiler or process water
- Irrigation of golf courses
- Irrigation in urban areas: landscape and sport fields irrigation
- Aquaculture

Widely practised and with high social value

- Agricultural irrigation of industrial crops, orchards, vineyards or crops eaten cooked using surface, spray, drip and/or subsurface irrigation

Emerging

- Aquifer recharge
- Augmentation of drinking water reservoirs
- Restoration of water bodies and wetlands
- Non-potable urban uses such as street cleaning, fire protection, car washing, toilet flushing
- Irrigation of nurseries
- Agricultural irrigation of vegetables and high values crops

Water Reuse Challenges

Public health and regulatory concerns

- Health issues related to pathogens or chemicals if wastewater is not properly treated
- Lack of adequate regulations and local incentives for reuse

Economical and financial barriers

- Inadequate water pricing and problems for cost recovery
- Need of high investment for distribution networks and funding for adequate monitoring
- Uncertainties in supply contracts and pricing
- Insufficient financial and economic incentives
- Lack of appropriate models for cost & benefit analysis

Technical and environmental constraints

- Need of high reliability of operation and water quality control
- Land salinisation or soil toxicity
- Technical competence and staff training

WATER RECYCLING AND REUSE REGULATIONS

Water recycling regulations and guidelines are aimed at the protection of public health, principally against infectious diseases caused by microbial pathogens. Criteria vary with the type of application, the regional context and the overall risk perception and they are expressed as quality requirements, recommendations of treatment processess and indications for operational reliability. As yet, no reliable epidemiological evidence of disease outbreaks caused by adequately recycled water has been reported. The 3rd edition of the WHO guidelines provides a new health-based approach for water reuse in irrigation providing the flexibility to adapt to local circumstances, taking into account other health protection barriers beyond wastewater treatment. Adequate monitoring of system installation, consumer changes, water quality inputs and outputs, land quality, environment quality, and system performance must be funded and instituted.

KEYS TO SUCCESS IN WATER RECYCLING AND REUSE

The major key to success in water recycling and reuse in terms of health safety and economic viability is the **rational combination of wastewater treatment and best practices in the application sites**. This approach is very important for agricultural irrigation, which supports food security, as well as for golf course and landscape irrigation, for which recycled water is becoming inevitable alternative resource in dry and urban areas. Source control is beneficial for the diversification of water reuse, e.g. limiting industrial discharges, on-site recycling, urine separation, reduction of salt discharge or intrusion into sewers, etc.

Political decisions, clearer institutional arrangements, financial incentives, policy on environmental protection and **economic instruments** are critical for the viability and the cost competitiveness of water reuse projects. Water reuse is still suffering from the under evaluated and subsidized conventional water resources and constraints for the application of "full-cost recovery" and "polluter-pays" principles.

Stakeholders' involvement in water recycling and reuse projects and their perception of the water cycle management is unquestionably the crucial factor for the success and the future development of water reuse practices, in particular in urban areas, agriculture and for indirect potable reuse.

The emerging issues of **climate change**, the **European Water Framework Directives** and the **Millennium Development Goals** are expected to favor water recycling and reuse development as water recycling is widely recognized as a proven water scarcity solution, drought-proof alternative resource and environment protection approach.

TECHNICAL CHALLENGES AND INNOVATION

The technical factor is often considered as least important for the success of water reuse projects as today's available technologies make it possible to reach any water quality required by users and for regulatory compliance. The range of technologies that can been applied is broad, from the well-proven standard ones to the newest advanced types. However, the final choice will be strongly dependent upon local conditions, plant size and water quality standards. An adequate choice, which means the selection of the most appropriate or "the best available" technology in a given situation, plays a key role for its future reliable operation and provides the guarantee of having a suitable water quality at lower operation and maintenance costs.

To achieve an adequate disinfection performance, in which fecal indicators are to be kept below the detection limits, it is recommended to implement a pre-treatment to decrease the concentration of suspended solids. This is of special importance if UV light is used as disinfection agent. The combination of UV with other disinfection agents provides a greater reliability and higher efficiency for inactivation of different types of microorganisms .

During the last decades, membrane treatment has been approved as the best available technology for the production of high quality recycled water for indirect potable reuse and industrial applications. Among the membrane processes used for wastewater treatment, membrane bioreactor (MBR) technology is advancing the most rapidly worldwide. Microfiltration (MF) and ultrafiltration (UF) are becoming the preferred pre-treatment options before reverse osmosis (RO).

Increasing concerns on low carbon emissions and sustainability are giving a new interest in non-conventional technologies such as soil-aquifer treatment, stabilization ponds, and wetlands both as secondary treatment and polishing. Decentralized treatment plays an increasing role in water recycling both in urban and rural areas.

HEALTH AND ENVIRONMENT CONCERNS

Water quality is the most important issue in water reuse system that determines the acceptability and safety of use of recycled water for a given application. For each purpose, the definition of appropriate water quality is driven by a number of health, safety, socio-psychological and technical-economic criteria. As a rule, water quality objectives are set by guidelines and regulations, which in turn determine the treatment technology to be used. **Assurance of treatment reliability and the good operation of water recycling and reuse system is the major water quality control measure**. A thorough knowledge and appropriate monitoring of input and output water quality is needed to protect public health and minimize the negative impacts of recycled water on environment, water bodies and/or irrigated crops. In addition to the principal health protection measure that is wastewater treatment, it is very important to implement and enforce **codes of good practice**.

Despite the number of recognized environmental benefits, the implementation of water reuse systems may result in **negative environmental impacts that must be assessed**. Adverse impacts on environment include alteration of land use, impacts on wetlands and ecosystems, effects on soils, plants and aquifers. Emerging contaminants, in particular endocrine disruptors and pharmaceutically active chemicals, are becoming a concern for environment protection and health safety for indirect potable reuse schemes. These compounds create unique challenges both for their detection and removal at very low trace level. Advanced treatment technologies such as activated carbon, reverse osmosis and advanced oxidation appear to be viable solutions.

SOCIAL AND ECONOMIC CONSIDERATIONS

The value of recycled water is determined by the use to which it is put and/or the benefits arising from its implementation. Full cost recovery is desirable, but it should be analyzed from a global water cycle perspective, to include those who benefit indirectly from the water recycling projects.

The type and scale of benefits and costs of water recycling and reuse are very location specific. Generally, water recycling benefits and the value of water are highest where available natural water supply, in terms of quantity, price, reliability and quality, acts as a major constraint on economic activities, such as crop growth, industrial production and tourist activities. The costs can be minimised by substituting recycled water for the largest water users requiring the minimum of treatment and additional monitoring, or the least distance from the treatment plant. There is an optimum size of the collection area where the cost of additional piping for collection and redistribution exceeds the savings on economies of scale of the treatment plant.

FURTHER INFORMATION

The following publications may serve as valuable resources in the implementation of water recycling and reuse in various applications.

IWA International Water Association
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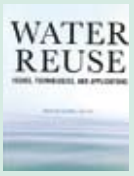
Web links
http://www.epa.gov
http://www.watereuse.org

Australian Guidelines for Water Recycling. Managing Health and Environmental Risks
www.ephc.gov.au/taxonomy/term/39

USEPA Guidelines for Water Reuse (2004)
http://www.epa.gov/region/water/recycling/index.html

Guidelines for the Safe Use of Wastewater, Excreta and Greywater, vol.II Wastewater Use in Agriculture
World Health Organization (2006)
©WHO 2006

ISBN 92 4 154686 7(set)
ISBN 92 4 154683 2 (v.2)

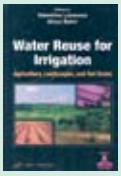


Water Reuse: Issues, Technologies, and Applications
Asano, T., F. L. Burton, H. Leverenz, R. Tsuchihashi, and G. Tchobanoglous (2007)

McGraw-Hill, New York
ISBN 0071459278

Water Reuse: An International Survey of Current Practice, Issues and Needs
Jimenez, B. and T. Asano (Ed.) (2008)

IWA Publishing, London, UK
ISBN: 9781843390893



Water Reuse for Irrigation: Agriculture, Landscapes, and Turf Grass
Lazarova, V. and A. Bahri (Ed.) (2005)

CRC Press, Boca Raton, FL
ISBN-10: 1566706491

Water Science and Technology
Editor in Chief: Gustaf Olsson

IWA Journal

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